Tests Evaluate Strength of Manufacturer's Joint

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ASSI

AN EXTENSIVE series of studies has been completed at Packforsk (the Swedish Packaging Research Institute) by the commission of the Swedish Development Group for Corrugated Board to establish the strength of the manufacturer's joint in relation to the impact material of corrugated boxes. The evaluation was based on a drop test because an introductory investigation showed that the manufacturer's joint in all corrugated board grades was strong enough to withstand stacking stresses at relative humidities of 50 to 80 per cent.

SUW, an abbreviation of Svenska Utvecklingsgruppen för Wellpapp (Swedish Development Group for Corrugated Board), was formed in 1968 by the four large paper and corrugated board companies in Sweden: AB Statens Skogsindustrier (ASSI), Billerud AB, Fiskeby AB and Svenska Cellulosa AB (SCA). The purpose of the work of the SUW group is to:

1. Study the influence of the properties of the raw material on the properties of the end product.

2. Follow and take part in the work on standardization of corrugated board in domestic and international organizations.

3. Study the present and potential fields of application for corrugated board and promote increased usage.

4. Study the factors that influence and interfere with the production of corrugated board.

5. Study the factors influencing and interfering with the conversion of corrugated board into packages.

SUW's activity is directed by a steering committee of eight members—two from each of the four companies—and by various project committees. The SUW group works closely with the Swedish Packaging Research Institute. ■

Boxes with glued and stapled joints of single-wall C-flute board were tested. Their size was 400 x 300 x 300 mm (approximately 16 x 12 x 12 in.). The glue-line bond was made with normal, non-wet-strength starch adhesive. The grades tested are shown in Table 1.

Method

Prior to drop testing, the boxes were completely filled with dried peas (weight 33.5 kg—approximately 74 lb.) and sealed with glass fibre reinforced adhesive tape. The tests were conducted on a concrete surface and the boxes were dropped only on their edges. The tests were carried out in the form of gravity center drops. The damage drop height was defined as the drop height from which the box was damaged to such an extent that it leaked.

The boxes were aligned in such a way as to subject the manufacturer's joint to the greatest possible stresses along the three main axes of each box. Testing began at a drop height of 7.5 cm (3 in.) with three drops. The drop height was then increased at intervals of 7.5 cm, three drops being made from each height. A note was made of the number of drops and of the damage drop height.

Five boxes of each grade were drop tested after conditioning at 23 deg. C and 50 per cent relative humidity, and five more after conditioning at 23 deg. C and 80 per cent RH. Tests on grades rupturing after drop No. 10 were started at 50 per cent of the anticipated number of drops.

Results

From the detailed results (Table 2) the following conclusions can be drawn:

1. The drop height for boxes with a stapled joint is lower than for boxes with a glued manufacturer's joint.

2. Greater humidity increases the damage drop height for boxes with a glued manufacturer's joint.

3. Damage drop height does not vary with humidity for boxes with stapled manufacturer's joints.

4. The damage drop height for test liner boxes (150/112/150 g/m²) with glued manufacturer's joints is lower than for kraft liner boxes of lower weight (125/112/125 g/m²) and also lower than for kraft liner boxes of the same or greater weight.

5. The damage drop height for test liner boxes (150/112/150 g/m²) with stapled manufacturer's joints is lower than for kraft liner boxes of the same weight (no others were tested).

The following observations can also be made concerning the frequencies of different types of damage:

1. In boxes with stapled joints, damage invariably occurs in the manufacturer's joint.

2. Greater humidity increases the proportion of joint damage occurring in boxes with glued manufacturer's joints.

3. The proportion of damage to the joint in test-liner boxes (150/112/150 g/m²) with glued manufacturer's joints is lower than for kraft-liner boxes of lower, identical or greater weight. The width of the manufacturer's joint was 23 mm for the inferior grades and 25-26 mm for the superior grades.

Damage Proportions

Drop testing proves that the proportion of damage to a manufacturer's joint and the damage drop height increase with increasing liner quality. The relationship between the ratio

$$\frac{\text{drop height}}{\text{manufacturer's joint width}}$$

and the proportion of damage to the manufacturer's joint is plotted on Figure 1. This shows that, in order to obtain the same proportion (e.g., 50 per cent) of damage to the manufacturer's joint for all grades, one can reduce the joint width of the inferior liner grades and increase the joint width of the superior liner grades.

From the above relationship the following can be concluded:

1. The manufacturer's joint is the weak point in stapled boxes, regardless of climate and liner quality.

BOXBOARD CONTAINERS MARCH 1975

Designation	Outer Liner	Medium	Inner Liner	Manufacturer's Joint
Test G	150 g/m² test	112 g/m² semi-chemical	150 g/m² test	Glued
SUW 12 G	125 g/m² kraft	ditto	125 g/m² kraft	Glued
SUW 14 G	150 g/m² kraft	ditto	150 g/m² kraft	Glued
SUW 16 G	200 g/m² kraft	ditto	200 g/m² kraft	Glued
Test S	150 g/m² test	ditto	150 g/m² test	Stapled
SUW 14 S	150 g/m² kraft	ditto	150 g/m² kraft	Stapled

Table 1. Grades of boxes tested.

	% RH	Test S	SUW 14 S	Test G	SUW 12 G	SUW 14 G	SUW 16 G
drop height to damage	50	18.0 cm	27.0 cm	18.0 cm	31.5 cm	31.5 cm	57.0 cm
	80	16.5 cm	27.0 cm	45.0 cm	61.5 cm	69.0 cm	78.0 cm
Percentage of manufacturer's joint damage	50	100%	100%	0%	0%	0%	20%
	80	100%	100%	20%	40%	80%	80%

Table 2. Mean recorded drop heights to damage and percentages of manufacturer's joint damage.

2. At 23 deg. C and 50 per cent RH, the manufacturer's joint is strong enough for glued boxes in drop testing. In test-liner grade and in kraft-liner grades of lower weight it is too strong.

3. At 23 deg. C and 80 per cent RH, the manufacturer's joint is a weak point in glued boxes in drop testing. This applies particularly to kraft-liner grades of greater weight. When the manufacturer's joint bursts, the damage does not occur in the "liner-liner joint" but in the glued lines and/or the paper material.

The relation between the drop height/manufacturer's joint width ratio and the proportion of damage to the joint shows that the following measures could be taken to improve liner utilization: (a) reduce the joint width of test-liner and inferior kraft-liner grades, and (b) increase the joint width of superior kraft-liner grades.

Liner Quality

As a result of the above deductions, a further study was completed to investigate the effect of the manufacturer's joint width on the proportion of damage to the joint occurring in different liner grades. Four grades were tested: test liner, SUW 12, SUW 14 and SUW 16, all of them with a range of joint widths.

Results are shown in Figures 2, 3, 4 and 5 for 30, 50, 60 and 80 per cent RH. The findings confirm those of the first study. They allow the following general conclusions:

Drop height: (1) increases, re-

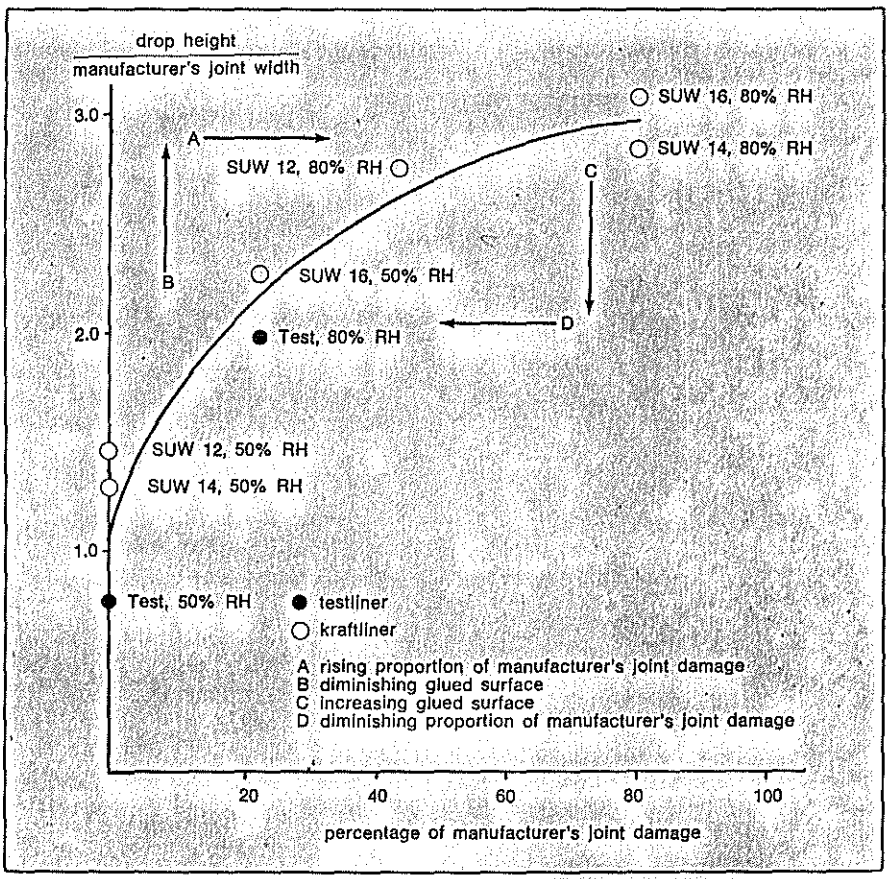

Figure 1. Relation between drop height ÷ manufacturer's joint width and proportion of manufacturer's joint damage.

As these photos show, gravity drop tests were conducted on a concrete surface. Boxes filled with 33.5 kg of dried peas were dropped only on their edges.

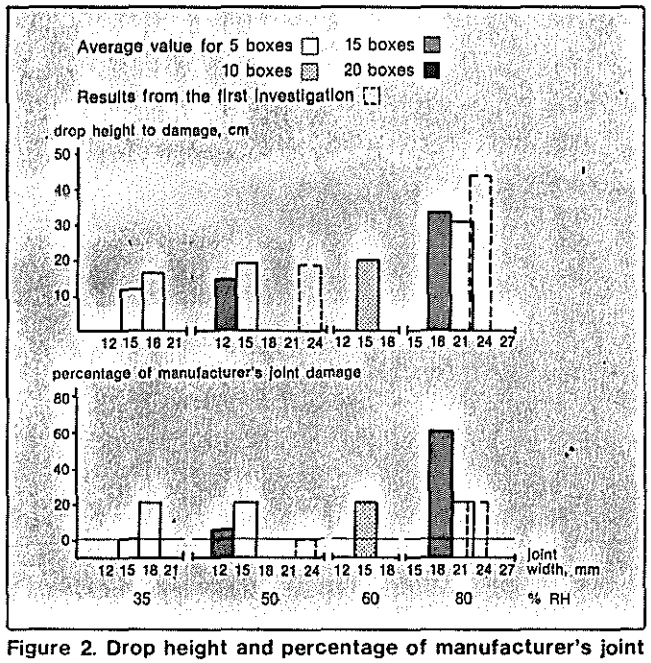

Figure 2. Drop height and percentage of manufacturer's joint damage for test grade.

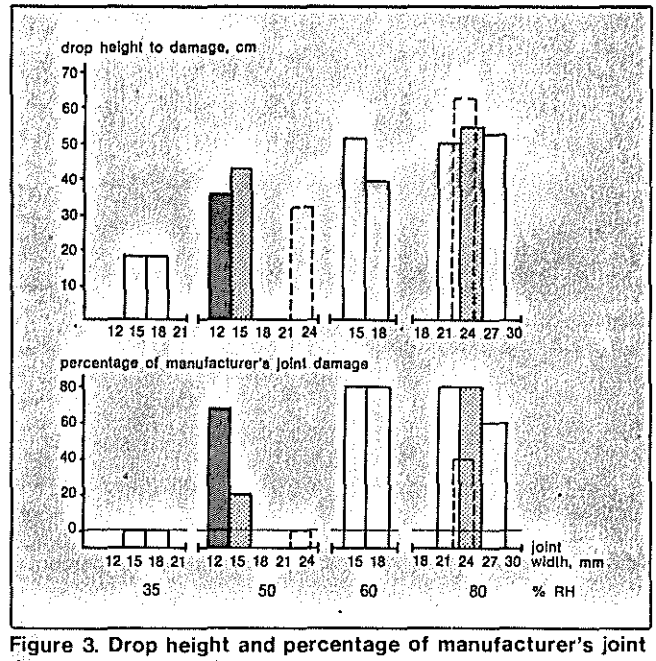

Figure 3. Drop height and percentage of manufacturer's joint damage for grade SUW 12.

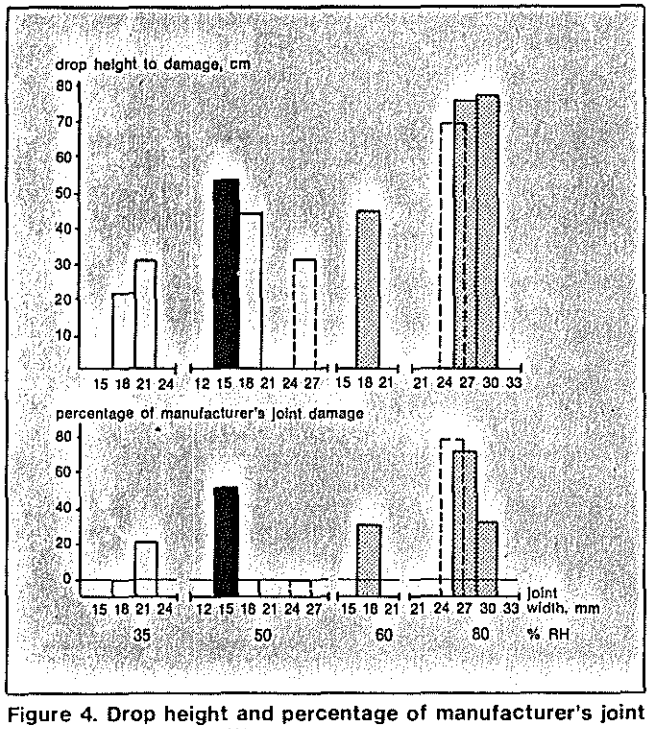

Figure 4. Drop height and percentage of manufacturer's joint damage for grade SUW 14.

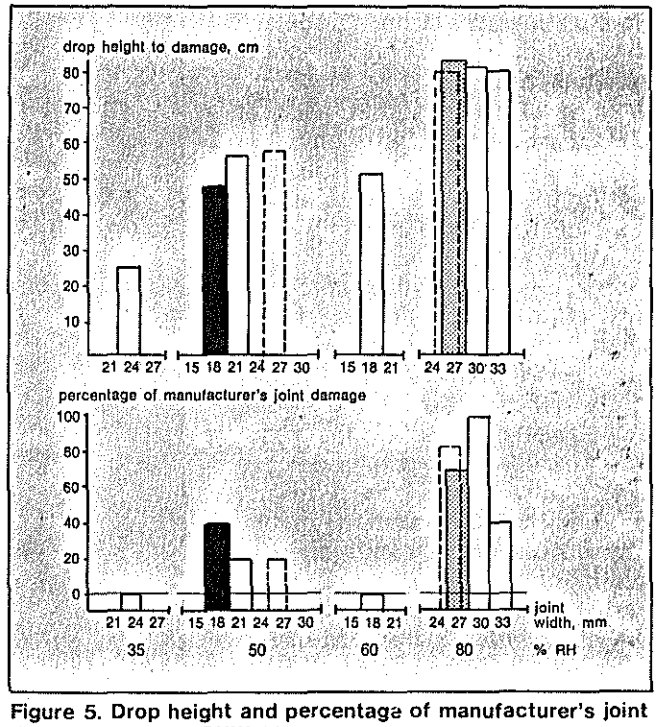

Figure 5. Drop height and percentage of manufacturer's joint damage for grade SUW 16.

duces or remains constant with the increasing joint width for the same grade and relative humidity; (2) increases with increasing relative humidity for the same quality joint width, and (3) increases with improved liner grade for the same quality and joint width.

Manufacturer's joint, damage percentage: (1) increases, reduces or remains constant with increasing joint width for the same grade and relative humidity; (2) increases with increasing relative humidity for the same grade and joint width, and (3) increases with improved liner grade for the same relative humidity and joint width.

Recommendations

The aim of the investigation was to facilitate the design of a homogenous box; i.e., a box where the strength of the manufacturer's joint is proportional to the strength properties of the box material. Basically, this means:

1. The higher the liner grade, the wider the manufacturer's joint required to obtain a homogenous construction.

2. The more humid the climate, the wider the manufacturer's joint required to obtain a homogenous construction.

Recommended widths are: *Low-grade liner*—low humidity, 12-18 mm; normal humidity, 15-21 mm; high humidity, 21-33 mm. *High grade liner*—low humidity, 15-21 mm; normal humidity, 18-27 mm; high humidity, 30-39 mm. ■